WHAT IS CLAIMED IS:

1. A method of making a metal part by semi-solid metal injection molding, comprising:

combining a first solid metal portion and a second liquid metal portion in a first chamber of an injection molding machine to form a semi-solid metal slurry; and

injecting the semi-solid metal slurry into a mold cavity to form a molded metal part.

2. The method of claim 1, wherein:

the first chamber comprises a shot chamber; and

the semi-solid metal slurry is injected from the shot chamber into the mold cavity.

3. The method of claim 2, wherein the first solid metal portion is provided into the shot chamber before the second liquid metal portion is provided into the shot chamber.

4. The method of claim 3, further comprising:

providing a grain refining agent into the shot chamber before providing the second liquid metal portion into the shot chamber; or

providing the grain refining agent into the second liquid metal portion before providing the second liquid metal portion into the shot chamber.

5. The method of claim 4, wherein:

a combined volume of the slurry comprising the grain refining agent, the first solid metal portion and the second liquid metal portion is substantially equal to a volume of the mold cavity; and

a latent heat of the second liquid metal portion is sufficient to bring a temperature of the combined volume into a semi solid state.

6. The method of claim 5, wherein the metal comprises aluminum or an aluminum alloy.

7. The method of claim 6, wherein the metal comprises a hypereutectic alloy.

8. The method of claim 7, wherein the metal comprises a 390 alloy.

9. The method of claim 8, wherein the temperature of the semi-solid metal slurry is between 560 °C and 590 °C.

10. The method of claim 7, wherein the grain refining agent comprises a phosphorus containing alloy or a phosphorous bearing salt.

11. The method of claim 10, wherein the grain refining agent comprises an alloy containing copper and phosphorus, an alloy containing aluminum, copper and phosphorus or a phosphorous-bearing salt.

12. The method of claim 6, wherein the metal comprises a hypoeutectic or a non-silicon bearing alloy.

13. The method of claim 12, wherein the metal comprises an A356 alloy.

14. The method of claim 13, wherein the temperature of the semi-solid metal slurry is between 575 °C and 585 °C.

15. The method of claim 1, wherein the first solid metal portion and the second liquid metal portion comprise the same metal or metal alloy.

16. The method of claim 1, wherein the first solid metal portion comprises a solid grain refining agent which is adapted to refine grains of a second metal alloy and the second liquid metal portion comprises the second metal alloy.

17. The method of claim 13, wherein the grain refining agent comprises an alloy containing titanium, or boron or combinations thereof.

18. The method of claim 5, wherein the first solid metal portion comprises 5 to 30 volume percent of the combined volume of the semi-solid metal slurry in the shot chamber.

19. The method of claim 1, further comprising:

removing a third solid metal portion of the molded metal part; and

providing the third solid metal portion into the first chamber of the injection molding machine during a subsequent step of forming a subsequent molded metal part.

20. The method of claim 19, wherein the mold cavity includes a secondary cavity portion, the secondary cavity portion having a volume substantially equal to the third solid metal portion.

21. The method of claim 20, wherein the secondary cavity portion has a surface area to volume ratio of at least 5:1.

22. The method of claim 21, wherein the surface area to volume ratio is greater than 10:1.

23. The method of claim 21, wherein the secondary cavity portion contains fin or spike shaped regions to form the third solid metal portion having fins or spikes.

24. The method of claim 20, further comprising placing a grain refinement agent into the secondary cavity portion prior to injecting the semi-solid metal into the mold cavity, such that the grain refinement agent is entrapped in the third solid metal portion.

25. The method of claim 2, wherein the shot chamber comprises a vertically oriented shot chamber having a horizontal width that is at least two times greater than a vertical depth of melt in the chamber.

26. The method of claim 25, wherein:

the semi-solid slurry forms in the shot chamber with a generally globular or equiaxed primary phase microstructure without stirring the semi-solid slurry; and

the semi-solid slurry is injected into a mold cavity by advancing a shot piston upwardly in the shot chamber.

27. A molded metal part made by the method of claim 1.

28. The part of claim 19, wherein the part comprises a first region that is richer in primary particles than a second region.

29. A method of making a metal part by semi-solid metal injection molding, comprising:

providing a solid metal heat sink into a shot chamber of an injection molding machine;

providing liquid metal over the heat sink to form a semi-solid metal slurry; and

injecting the semi-solid metal slurry into a mold cavity to form a molded metal part.

30. The method of claim 29, further comprising

providing a grain refining agent into shot chamber before providing the liquid metal into the shot chamber; or

providing liquid metal including a grain refining agent.

31. The method of claim 30, wherein:

a combined volume of the slurry comprising the grain refining agent, the first solid metal portion and the second liquid metal portion is substantially equal to a volume of the mold cavity; and

a latent heat of the second liquid metal portion is sufficient to bring a temperature of the combined volume into a semi solid state.

32. The method of claim 31, wherein:

the metal comprises a hypereutectic aluminum alloy;

the temperature of the semi-solid metal slurry is between 505 °C and 600 °C; and

the grain refining agent comprises a phosphorus containing alloy or a phosphorous bearing salt.

33. The method of claim 32, wherein:

the metal comprises a 390 aluminum alloy;

the temperature of the semi-solid metal slurry is between 560 °C and 590 °C; and

the grain refining agent comprises an alloy containing copper and phosphorus, an alloy containing aluminum, copper and phosphorus or phosphorous-bearing salt.

34. The method of claim 31, wherein:

the metal comprises a hypoeutectic or a non-silicon bearing aluminum alloy;

the temperature of the semi-solid metal slurry is between 560 °C and 600 °C; and

the grain refining agent comprises an alloy containing titanium, or boron or combinations thereof.

35. The method of claim 34, wherein:

the metal comprises an A356 aluminum alloy;

the temperature of the semi-solid metal slurry is between 575 °C and 585 °C.

36. The method of claim 31, wherein the heat sink comprises 5 to 30 volume percent of the combined volume of the semi-solid slurry in the shot chamber.

37. The method of claim 36, further comprising:

removing an appendage from the molded metal part; and

providing the appendage back into the shot chamber of the injection molding machine during a subsequent step of forming a subsequent molded metal part.

38. The method of claim 37, wherein:

the mold cavity includes a secondary cavity portion, the secondary cavity portion having a volume substantially equal to the appendage;

the secondary cavity portion has a surface area to volume ratio of at least 5:1.

39. The method of claim 38, further comprising placing a grain refinement agent into the secondary cavity portion prior to injecting the semi-solid metal into the mold cavity, such that the grain refinement agent is entrapped in the appendage.

40. The method of claim 29, wherein:

the shot chamber comprises a vertically oriented shot chamber having a horizontal width that is at least two times greater than a vertical depth of melt in the shot chamber;

the semi-solid slurry forms in the shot chamber with a generally globular or equiaxed primary phase microstructure without stirring the semi-solid slurry; and

the semi-solid slurry is injected into a mold cavity by advancing a shot piston upwardly in the shot chamber.

41. The method of claim 29, wherein the solid metal heat sink and the liquid metal comprise the same metal or metal alloy.

42. The method of claim 29, wherein the solid metal heat sink comprises a solid grain refining agent which is adapted to refine grains of a second metal alloy and the liquid metal comprises the second metal alloy.

43. A molded metal part made by the method of claim 29.

44. A method of making a metal part by semi-solid metal injection molding, comprising:

providing a solid metal heat sink into a shot chamber of an injection molding machine, wherein the shot chamber comprises a vertically oriented shot chamber having a horizontal width that is at least two times greater than a vertical depth of melt in the chamber;

providing a grain refining agent into shot chamber;

providing liquid metal over the heat sink and the grain refining agent to form a semi-solid metal slurry, wherein the semi-solid slurry forms in the shot chamber with a generally globular or equiaxed primary phase microstructure without stirring the semi-solid slurry;

injecting the semi-solid metal slurry from the shot chamber into a mold cavity to form a molded metal part having an appendage;

removing the appendage from the molded metal part; and

providing the appendage back into the shot chamber of the injection molding machine as a heat sink during a subsequent step of forming a subsequent molded metal part.

45. The method of claim 44, wherein:

a combined volume of the slurry comprising the grain refining agent, the first solid metal portion and the second liquid metal portion is substantially equal to a volume of the mold cavity; and

a latent heat of the second liquid metal portion is sufficient to bring a temperature of the combined volume into a semi solid state.

46. The method of claim 44, wherein the metal comprises a hypereutectic alloy.

47. The method of claim 46, wherein:

the temperature of the semi-solid metal slurry is between 505 °C and 600 °C; and

the grain refining agent comprises a phosphorus containing alloy or a phosphorous bearing salt.

48. The method of claim 47, wherein:

the metal comprises a 390 aluminum alloy; and

the temperature of the semi-solid metal slurry is between 560 °C and 590 °C; and

the grain refining agent comprises a copper and phosphorus containing alloy.

49. The method of claim 44, wherein the metal comprises a hypoeutectic or a non-silicon bearing alloy.

50. The method of claim 49, wherein:

the temperature of the semi-solid metal slurry is between 560 °C and 600 °C; and

the grain refining agent comprises an alloy containing titanium, or boron or combinations thereof.

51. The method of claim 50, wherein:

the metal comprises an A356 aluminum alloy;

the temperature of the semi-solid metal slurry is between 575 °C and 585 °C.

52. The method of claim 45, wherein the heat sink comprises 5 to 30 volume percent of the combined volume of the semi-solid slurry in the shot chamber.

53. The method of claim 52, wherein:

the mold cavity includes a secondary cavity portion, the secondary cavity portion having a volume substantially equal to the appendage;

the secondary cavity portion has a surface area to volume ratio of at least 5:1.

54. The method of claim 44, further comprising placing a grain refinement agent into the secondary cavity portion prior to injecting the semi-solid metal into the mold cavity, such that the grain refinement agent is entrapped in the appendage.

55. The method of claim 44, wherein the solid metal heat sink and the liquid metal comprise the same metal or metal alloy.

56. The method of claim 55, wherein the solid metal sink further comprises a grain refining agent which is adapted to refine grains of a second metal alloy and liquid metal comprises the second metal alloy.

57. A molded metal part made by the method of claim 44.